Organic agricultural production is increasing at exponential rates. Consumers are indicating that they will pay a higher price for organically grown food sources, as evidenced by the immense success of large chain organic food markets in the US. However, there are many misconceptions concerning organic production and what exactly comprises an organic food source. This article attempts to define the current standards evolving in terms of organic aquaculture feeds, indicates potential paths this new and emerging field might be taking and discusses the limited research that has been conducted to this point in time.

Organic Aquaculture Feeds

Steven R. Craig, Ph.D.
Associate Professor, Department of Large Animal Clinical Sciences, Virginia-Maryland Regional College of Veterinary Medicine, Phase II, Duckpond Drive
Blacksburg, VA 24061, USA
Scraig@vt.edu

Definitions

Although organically produced foodstuffs have been available for quite some time and standards are in place for many of the terrestrial food production sectors, there is still a lot of confusion as to what exactly constitutes "organic." "Organically produced", or "100% organic" are not simply terms applied at one's discretion, rather they provide an indication as to the process of production. "Natural" does not equate with "Organic", although many consumers tend to group the designations together. An umbrella group, the International Federation of Organic Agriculture Movements (IFOAM) has been the central determining body in drawing up and finalizing organic standards for aquaculture and agriculture. The European Union (EU) has adopted guidelines for organically produced aquaculture products and they have been in effect since 1998. In the US, permanent actions have not been taken with regard to organic aquaculture standards, although the National Organic Standards Board (NOSB) of the USDA has formed an Aquatic Animal Task Force (AATF) to develop and implement standards for aquaculture products. The USDA has also established the National Organic Aquaculture Working Group (NOAWG) to aid in the drafting of organic standards that can then be adopted through interaction with the NOSB and the USDA. The NOAWG comprises of members from academia, industry (both feed and aquaculture), non-governmental organizations, the NOSB and the federal government that is working to prepare a document to serve as the guideline for USDA organic aquaculture standards. This work is proceeding rapidly and the final document should be in place in the very near future. Issues currently being addressed within the NOAWG pertain to feed issues, primarily the use of fish meal and fish oil in organic aqua feeds. Current standards in place for aquaculture in the US are based upon those guidelines presently in place for terrestrial organic agriculture, as well as some of those adopted by the EU and other countries. Table 1 outlines various standards as they relate to vitamin, mineral and fish meal/oil inclusion in organic aqua feed rations. Certainly, the desire is for standardized international guidelines and requirements for organic labeling so that there is little confusion when consumers see a seal or stamp of approval on a product signifying it as organically produced, regardless of where the product was produced.

Finding alternative, traceable, high quality protein to fishmeal is a key area of organic aqua feeds research.

Photo Courtesy: Dr. Brett Glencross.

Organic aquaculture nutrition

Research into organic formulations has been steadily increasing over the last several years. However, since the standards for organic production of finfish and crustaceans are under development and thus, subject to change and revision, nutritional research has progressed slowly. As with general aquaculture nutrition, a priority area of research in organic aquaculture nutrition is the reduction and possible elimination of fish meal and fish oil in feeds (discussed later in this paper). However, every feedstuff and supplements that are already on the National List of Allowed Substances requires further investigation. Residence on the National List is renewable every five years. Standards could be modified and further strengthened in the future to protect the organic labeling process and procedures. Therefore, compounds or feedstuffs presently on the list are by no means secured for the future. Other important areas of organic aquaculture feeds research are alternatives to feedstuffs containing genetically modified organisms (GMO) and development of traceability for ingredients.

Table 1: Comparison of standards from various organic aquaculture standards boards.

Feed Issues	IFOAM[1]	CAAQ[2]	COABC[3]
Vitamins/Minerals	Synthetics allowed if organics not available in sufficient quantities	Synthetics allowed if organics not available in sufficient quantities	Synthetics allowed if organics not available in sufficient quantities
Fish meal/oil	By-products from food grade fisheries allowed. For limited periods can utilize meal/oil from feed grade fisheries, but not more than 50% of diet and must be from certifiable sustainable fishery	Wild fish, little or no pollution or from organic fisheries and fish farms. Recommendations that fish meal/oil be added to CAAQ list of approved supplements for aquaculture	By-products from wild caught fish for human consumption, preference for local sources. Meal/oil from dedicated fisheries must be independently verified as sustainable
Non-organic feed restrictions	Not to exceed 15% (dry weight) per year	Not to exceed 15% (dry weight) per year	Time limited-up to discretion of certifying body

1 - International Federation of Organic Agriculture Movements. Taken from IBS 2nd Revision Draft, January 2003
2 - Conseil des Appellations Agroalimentaires du Québec (CAAQ) is the official provincial authority for managing and monitoring reserved agri-food appellations in Quebec. Taken from Standards Project Organic Aquaculture July 14, 2004
3 - Certified Organic Associations of British Columbia. Taken from Draft Discussion Document, Organic Aquaculture Production Standards March 2004.

Fish meal and fish oil in organic feeds

Current organic standards in the EU stipulate that fish meal included in aqua feeds must be from scraps and by-products from fish destined for human consumption or from a wild caught fishery that has been certified as sustainable. Most certified producers in the EU who utilize fish meal in aqua feeds rely upon the human consumption source. Alternate organic protein sources to fish meal from wild caught fisheries or even the development of organically certified fish meal sources remain one of the major limiting factors impeding organic feed development and consequently, growth of organic aquaculture production, especially when dealing with carnivorous species. There are, however, suitable species, mainly herbivores and omnivores, which do not require high levels of fish meal in their diets. Species such as tilapia and catfish lend themselves well to organic production from a feed perspective and these species should be fairly easy to convert over to organic production. The controversy over fish meal has intensified with recent reports of PCB and heavy metal contamination in products from this industry and these issues have been addressed in the three certifying documents presented in Table 1. Generally speaking, fish meal and oil inclusion in organic aqua feeds appears acceptable in the near future based upon the aspects of organic aquaculture production that require natural feeding tendencies and health requirements of carnivorous species to be optimized, as long as the limits and restrictions are met (see Table 1). It is fully expected by all involved that organic standards concerning fish meal and fish oil will change in the future, with more limitations on the use of these ingredients. While increased constraints on fish meal and oil inclusion in organic aquaculture certainly will restrict the species that can be considered for organic culture, current standards will allow for the organic culture of carnivorous species. For these species, research on fish meal and fish oil substitution meshes nicely with the current trends in aquaculture nutrition to reduce the dependence on capture fisheries.

GMO and traceability

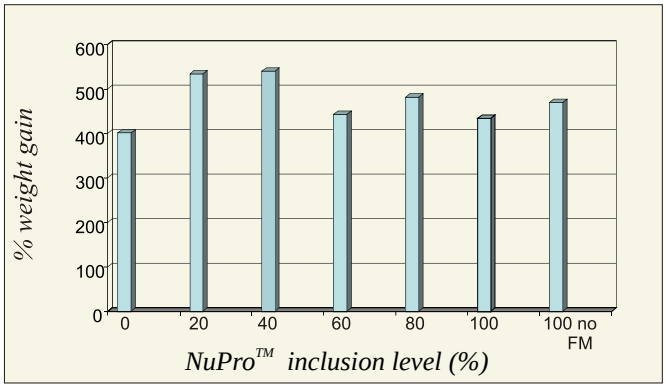
An important area of concern with regards to organic standards is the current inability to utilize genetically modified organisms (GMO) including soybean and corn meals from GMO plants. Protein sources from GMO are strictly forbidden in all drafts of organic standards worldwide. This limits the available sources of high protein, highly digestible, cost-effective feedstuffs that can be utilized in aqua feeds. Another challenge is the ability to track and certify feedstuffs for use in organic feeds.

Traceability is important not only in the organic certification process, but also in food safety and biosecurity. The traceability issue will become increasingly important as organic standards are developed, revised and become more stringent. Therefore, research should be directed towards protein and oil sources that are completely traceable and certifiable in terms of organic standards.

At Virginia Tech, our program has initiated research into several promising protein sources that are fully traceable and certifiable. Preliminary results indicate that these sources can completely replace soybean meal in diets designed for tilapia without impacting growth performance. One of these sources, NuPro™ (Alltech Inc., Nicholasville, KY), appears to be a highly promising candidate to replace fish meal in aqua feeds based upon its relatively high protein content (51-55% crude protein), an amino acid profile that mimics casein and its ability to be fully certified as an organic protein source. Although this product is presently as expensive as other potential organic protein sources, the higher gate value of an organically certified product combined with higher demand for this protein source

in commercial aqua feeds could exceed the ingredient cost increase from NuPro™ inclusion in organic aquafeeds. NuPro™ also contains a "soup" of compounds ranging from nucleotides to peptides and other constituents of the cytoplasm from the yeast cell. As such, there are many additional benefits that may be incurred by including this novel protein source in aqua feeds, specifically enhancement of immune status in cultured fish which would have a direct impact on aquacultural production and viability.

Figure 1. Weight gain (percent increase in initial weight) in tilapia fed diets containing increasing levels of dietary NuPro™



Research in our laboratory has proven that NuPro™ can effectively serve as the sole protein source in aqua feeds designed for tilapia without negative impacts on growth, feed efficiency, and most importantly, final product quality. Figure 1 shows the weight gain data from a feeding trial recently completed at the Virginia Tech Aquaculture Center. In this trial, a standard experimental feed designed for tilapia, containing 38% crude protein (34% from soybean meal, 4% from fish meal), and 8% lipid was used as a control diet. The other seven experimental diets were formulated so that NuPro™ replaced the soybean meal component of dietary protein at levels of 20, 40, 60, 80 and 100%, with an additional diet containing solely NuPro™ as the intact protein source (without soybean meal or fish meal). All these diets outperformed the control diet, with higher weight gain responses ranging from 9 to 35% above that of the control diet. There were no significant differences in feed efficiency ratio values, or filet proximate composition.

A commercial field trial involving NuPro™ with the marine shrimp *Litopenaeus vannemei* also produced promising results. In a 22-week grow out trial at the Permian Sea Shrimp Company in Imperial, Texas, ponds that received NuPro™-supplemented diets had significantly greater weight gain compared with ponds fed a organically certified commercial shrimp diet (587% verses 386% increase from initial weight). The NuPro™ was included to reduce the fish meal in the certified shrimp diet to below 5% (the anticipated target inclusion level of fish meal for organic certification at the time). Average final weight of the shrimp fed the NuPro™-supplemented diets was approximately 19 g vs 12 g for shrimp fed the organically certified shrimp feed. These two trials certainly indicate that this organically certifiable protein source could serve as a basis for an aqua feed that could meet or exceed all present and future organic standards for certification.

Further trials are scheduled to investigate this and other sources of certifiable organic protein sources in diets for higher level carnivores such as cobia and flounder. Additionally, all future research will include sensory evaluations of the final product so that these new protein sources can be investigated not only in terms of their impacts on weight gain and health of the animal, but also from a consumer standpoint of final product quality. While this research undoubtedly shows promise, it must be added that currently, many of these protein sources are prohibitively expensive, as is the case with most fully traceable and certifiable protein sources. However, we feel that this area of research is paramount to establishing the ability to formulate feeds without GMO plants or fish meal, as the requirements for organic certification will most certainly not be relaxed, but will become more stringent in the future. It is with this frame of mind that our program is also directing research towards organic vitamins and minerals and the effects of their inclusion in organic aqua feed formulations.

Conclusions

One must bear in mind that the organic standards for aquaculture are in their infancy and will undergo substantial modification even after the initial standards are put into place. Research involving the organic production of aquaculture products is one of growing necessity. We must be able to supply certifiable and traceable aqua feeds for a wide range of species if this sector of our industry is to become established and flourish. Although a specific set of standards have not been adopted in the US, the NOAWG is moving ahead aggressively to establish these guidelines. Since these standards are subject to modification, researchers and producers can see the direction the industry is heading and must focus research to address the key issues that will inevitably impact organic aquaculture production. With this mindset, nutritional research should be more proactive, rather than reactive, with the hopes of increasing organic production of fish and shellfish for the growing consumer demand so that we can provide a safe, healthy and traceable food supply to the general public, as well as increased profitability for aquaculture production sector.

Dr. Steven Craig is an Associate Professor in the Department of Large Animal Clinical Sciences at the Virginia-Maryland Regional College of Veterinary Medicine on the campus of Virginia Polytechnic Institute and State University. Dr. Craig also holds a joint appointment in the Department of Fisheries and Wildlife Sciences at Virginia Tech and in that position, conducts his nutritional research at the Virginia Tech Aquaculture Center. His research program currently focuses upon quantitative nutritional requirements for emerging aquaculture species, development of species-specific diets for candidate species, investigation into alternative protein and lipid sources, organic nutritional research, interactions between nutrition and immune function and final product quality. Species currently investigated at Virginia Tech include summer and southern flounder, cobia, hybrid striped bass, yellow perch and tilapia. Dr. Craig is a member of the National Organic Standards Board Working Group recently constituted by the US Department of Agriculture.